Spectrum analyzer review - what's up with mixer?

\[
L_z \text{ last time } A_1 \cos (\omega_t t) \cdot A_2 \cos (\omega_L t) = \frac{1}{2} A_1 A_2 \left( \cos \left( \frac{\omega_R \cos (\omega_L t)}{2} + \frac{\omega_L}{2} \right) + \cos \left( \frac{\omega_R \cos (\omega_L t)}{2} - \frac{\omega_L}{2} \right) \right) \]

- Easy math = time, but signals often tricky/variable (e.g., \( \omega_L \))
- Want visual intuition

Recall \( \ast \) in time \( \rightarrow \ast \) in freq.

- In spec: \( \ast \) in
- Move signal across IF

Tracking is handy for making Bode plots... generates \( |S_{21}|^2 \)

Talking about noise & getting good models of noise voltage

- Why? (other than I like it)

- Minimum receivable signal \( \rightarrow \) range & data rate
  \( \rightarrow \) Detection threshold...etc.

- Max receivable signal \( \rightarrow \) mini range \( \rightarrow \) power handling
  \( \rightarrow \) interference resistance
What components fail as amplitude gets big?

- attenuators \( \tilde{V} \rightarrow \) resistors are linear
- antennas \( \tilde{V} \rightarrow \) fields are really linear
- mixers maybe \( \tilde{V} \rightarrow \) depends how they're built, but non-linear anyway
- filters probably not \( \tilde{V} \rightarrow \) LC RC linear
- power detectors yes \( \tilde{V} \rightarrow \) high rails saturate
- amplifiers yes \( \tilde{V} \rightarrow \) see power detectors

Full amplifier model
- pretend it's linear, but really has saturating nonlinearity

\[
V_i \rightarrow V_o = f(V_i) \quad \text{[Taylor expand]}
\]

\[
\approx a_0 + a_1 V_i \cos(\omega t) + a_2 V_i^2 \cos^2(\omega t) + \ldots
\]

- If input signal is sinusoidal \( V_i(t) = V_i \cos(\omega t) \)

\[
\approx a_0 + a_1 V_i \cos(\omega t) + a_2 V_i^2 \cos^2(\omega t) + a_3 V_i^3 \cos^3(\omega t)
\]

\[
= a_0 + a_1 (1 + \cos(2\omega t)) + a_2 V_i^2 (1 + \cos(2\omega t)) + \ldots
\]

DC gain

- 2nd order non-linearity creates DC offset
- 3rd harmonic
- In-band!

- 3rd order compression shrinks output by 1 dB \( (\Delta P_{\text{THD}}) \)

Achieve quality of amplifiers

- based on effect of these components

\( P_{\text{in}} = \text{input power to which } \)

\( \text{3rd order compression shrinks output by 1 dB } \)